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MILL AND SMELTER METHODS OF SAMPLING

By H. J. Stander.

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MILL AND SMELTER METHODS OF SAMPLING

(*By H. J. STANDER*).

The idea seems prevalent among men operating small properties in the mining districts of Arizona that the smelters and custom mills do, in many cases, give false returns on ores that are sent in for smelting or treatment. With a view to ascertaining the facts of the case, the Arizona State Bureau of Mines has conducted an investigation and has found that it would be utterly impractical for any smelter or mill to so falsify its method of sampling as to give low returns and still give the shipper one half of the sample to allow check assays to be made.

This bulletin is written with the idea of showing the small shipper how to sample, so that he may sample his ores before shipment and ascertain the correct valu,e so that he may have a check on the smelter. Smelter methods of sampling are also given, so that the reader may determine for himself, that, owing to the great changes in the routine and the large number of men that would be necessary in any falsifying system, the smelters could not afford to give incorrect returns.

Moreover, it must be considered that when the Copper Queen mine, for instance, ships to the Copper Queen smelter, the smelter purchases the ore precisely the same as they do the ore of the man who ships ten tons, and the sampling and umpires are done under the same conditions.

It may or it may not be true that the smelters charge exhorbitant rates, or make undue penalties, but it is certainly true that the assays made for the basis of settlement are from correct sampling.

The question of the selling of ores and information relative to the necessity for smelting charges, penalties, etc., will be discussed in a later bulletin.

The sampling of the ore forms a very important part of the operation carried out in a mill or a smelter. The reasons for systematic sampling in a concentrating plant or mill are not perhaps always the same as those in the case of a smelter. Where a company concentrates and smelts its own ore, the sampling in the mill is carried out more for a check on the work and an indication as to what is being done than for any other reasons, although the sampling here is of just as much importance as in the case where the mill sells the concentrated ore to a smelter. In the latter case, both parties usually have their own sampling departments.

When a lot of ore comes to a smelter, it is highly essential to know its composition and value. The value is calculated from assays and analyses made on various samples of the given lot of ore. One can easily see that these assays and analyses should be as near the correct figures as possible, because a very light variation in such figures may alter considerably the total value of the ore lot. It is possible to assay and analyze quite accurately, and the results will be quite satisfactory, provided the samples used truly represent the lots of ore.

One of the chief problems, then, to be faced by the mill or smelter, is to obtain true samples of the ore. Such sampling must necessarily be accurate if ores or metallurgical products are sold by one and bought by another company, as the total value of the ore is always calculated from the assays and analyses of the samples. We have in the United States public sampling and ore-purchasing companies, who act as disinterested parties between buyer and seller, sampling the ore for a fixed charge per ton. It is very easy to see that these sampling companies greatly facilitate the selling and buying of an ore.

Most milling and smelting companies have their own sampling departments, and always sample an ore as it comes in, whether it had been sampled previous to its shipment or not. It is impossible for such a company to treat each ore sep-

arately, both because of the cost and because of technical difficulties. Mills and smelters work continuously, and a shut down, for however short a period, means a loss in labor, power, etc., and thus to allow one lot of ore to be heated altogether by itself is a practical impossibility. From this, it is quite clear that the only way of ascertaining the amount of the valuable metals in the ore lot is by assaying and analyzing true samples of the ore.

Before discussing in full the smelter methods of sampling, it may be well to note how sampling is usually carried out in an assay or metallurgical laboratory. As every lot or sample of ore comes into the laboratory, it has a number or name attached to it. The assayer keeps a very careful record of all data in a record note-book, in which he puts down the date received, name, number, and any other necessary information. Should the sample have no number, he gives it an arbitrary one, which can be identified in the future. After all this information has been recorded, he next finds the gross weight, and if the ore is wet, two samples are taken and the moisture determined. The ore is then thrown on the sampling floor. It is an easy matter at this stage to find the net weight of the ore, as it can be done by finding the weight of the sack, box or bottle in which the ore came, and subtracting this weight from the gross weight already found. At this stage some valuable information with regard to the character of the ore can be obtained, as the ore is still in a coarse condition.

Now comes the sampling, which is done by gradual crushing, mixing and sampling down. This sampling down is very often done by hand, and the method used is called the Cornish method. This method consists in coning the heap of ore on the sampling floor, then working it down into a circular shape and cutting it into quarters by making two diameters in the circle at right angles. The sample of ore has thus been thoroughly mixed and is divided into four parts, each part forming a segment of the circle. By removing two

opposite segments, and then mixing the two remaining parts together again, it becomes possible to cone half of the original amount of the ore. After it has again been coned, the operation of quartering it is repeated, and the amount is again halved. This operation is kept up until a small enough sample is obtained. The Cornish method is a common way of hand sampling and since hand sampling is still somewhat used in the smelters, it is well to be aquainted with it.

The hand sampling, as carried out in the smelter is, however, usually of a different character. It is commonly done at the smelter when the ore is unloaded by hand. As the ore is unloaded from the cars, or transferred from one place to another, the workman throws, say, every tenth shovelful on the sample heap. By this method, one tenth of the ore goes to the sample heap, which is again sampled down.

A sample may be taken from a stream of ore while it passes from one place to another, and in such a case it is called a "running sample." Such a running sample is taken either by hand or by machine, but where the sample is not taken from such a stream of ore, the sampling is done by hand.

DIFFICULTIES IN SAMPLING

When an ore contains the metals in the native form, or in small quantities of very high-grade materials, carried in barren gangue, the task of sampling is quite a hard one. It is easy to see that when the metal values are finely disseminated throughout the mass of the ore, the sampling is not so difficult as when the metal occurs in large masses or crystals. When one considers that the amount of ore assayed is only very small, one can realize that, should this assay-sample contain a larger or smaller percentage of crystals of the metal than there actually are in the ore, the results would be very misleading. It is thus necessary that the ore shall be crushed fine enough to distribute the metal values as evenly through the ore as possible, for even after such an ore has been

crushed to 70 mesh, it can easily happen that two samples, when assayed, will vary as high as 20 per cent. Such an ore frequently contains very rich particles of metal, which break off as crushing proceeds, and it is thus possible to come to a point where one has equally sized particles of nearly pure metal gangue. To get a true sample, it is thus necessary to continue the crushing until this point is reached.

REQUISITES TO ACCURACY

The first requisite to accuracy in sampling is that the sample and reject shall be uniform in composition at each stage of division. In order that this can be the case, there must be perfect mixing and very accurate dividing. After the sample has been cut down it should be recrushed sufficiently so that the ratio of the weight of the sample to the diameter of the largest particle in the sample shall not be below a safe proportion. If these conditions are carefully adhered to and thorough cleanliness is practiced throughout the entire operation, the limit of error is brought as low as possible.

The various ways of hand sampling will not be considered.

FRACTIONAL SELECTION BY SHOGEL

When the ore is moved by a shovel, either to load or unload it, every fifth, tenth or twentieth shovelful is thrown aside for a sample, as already noted above. How much of the ore shall be required for a sample—in other words, whether the workman shall throw on to the sample heap every fifth, tenth or twentieth shovelful, is always decided by the richness of the ore and the distribution of the minerals in it. In the same way, when loading or unloading ores in sacks, every fifth, tenth or twentieth sack may be set aside to form the sample. It is now necessary to crush this sample, and after it has been crushed the same operation of taking, say, every fifth shovelful, can be repeated. This al-

ternate cutting down of the sample and crushing it is kept up until a small enough sample is obtained. The Cornish method of sampling, as used in an assay laboratory, has already been outlined above, and quartering as used in smelters. ffl

CONING AND QUARTERING

As the crushed ore is brought into the sampling room, it is evenly deposited on the sampling floor in a large ring. The man then shovels the ore into a conical heal in the centre of the floor, while walking slowly around the ring. Only a certain amount of the ore should be shovelled up in passing once around the heap, because if too much of it is shovelled up, a part of the ore may be too much bunched. He should throw each shovelful upon the apex of the cone, thus allowing each shovelful to be evenly distributed on all sides of the cone.

When the operation has been completed, the ore is raked out into another ring by means of a shovel or hoe. It can now be once more coned or it may be shovelled into a new cone on another part of the floor. This process of reconing is repeated until the ore is satisfactorily mixed, and then the ore is flattened down to a ring once more. This last flattening down of the cone is usually done in a systematic way by walking around the heap and raking it down. The ore, in the shape of a flattened cone, is now quartered with a stick along two diameters at right angles to each other. Two opposite quarters are shovelled away and the two remaining ones are again worked into a heap. The same operation is repeated until the sample is small enough, a recrushing being done between each operation, if necessary. One difficulty is that the fine material tends to separate out of the coarser substances, and thus hinder thorough mixing. If the ore is somewhat damp, this difficulty is partly overcome. It is also highly essential that the sampling floor shall be level, clean and without cracks, and for this reason sampling floors are usually covered with iron plates.

THE SPLIT SHOVEL, RIFFLE AND JONES SAMPLER

The split shovel is a fork in which the prongs form separate scoops, each scoop being the same size as the space between two scoops. The split shovel is laid down on the ground and the ore is spread evenly over its surface. It is now raised, and the ore lying between the scoops is left on the ground while that in the scoops is thrown in a heap by itself. By this means the ore can be halved as many times as is desired.

The riffle is simply a large split shovel which has a small handle on each side, instead of one handle at the back as in the case of the ordinary split shovel. The Jones sampler has two sets of scoops of the same hize, sloping in opposite directions, instead of alternate scoops and spaces as in the case of a split shovel or riffle.

Using a Jones sampler, the ore is discharged by the two sets of scoops just as fast as it is poured on to the sampler, and is deposited in two separate heaps on the sampling floor. In these devices, it is customary to have each scoop at least four times as wide as the largest particle of ore.

Besides these devices there are also pipe and grab samples. A pipe sampler is one obtained by driving a cheese scoop sampler or pipe into the ore. This can, of course, be done while the ore is still in the sacks, cars or bins. A grab sample is one taken by dividing the surface part of the ore into squares and taking equal quantities of ore from the corners of the squares. Running samples are also sometimes taken by hand devices, such as dipping a bucket into the stream at given intervals.

An assay of an ore is always made on a dry sample, because it is impossible to obtain accurate results on a wet sample. The ore, on the other hand, is usually always damp when samples, and it is for this reason that it becomes necessary to get "moisture samples," from which the percentage of foisture in the ore can be determined. The moisture sample

is always taken just before or just after the ore is weighed and the method of obtaining such a moist sample must be a rapid one. The sample cannot be recrushed or cut down, as it has to be placed in a covered part immediately. By getting the weight of the moisture sample before any evaporation has taken place and its weight after it has been allowed to dry thoroughly and getting the difference of these two weights, one can determine how much moisture there was in the ore.

MECHANICAL SAMPLING

Some automatic samplers taken in part of the stream all of the time, whereas others take all of the stream part of the time. But as the values in an ore are never evenly distributed across the stream, the former is not so efficient a method as the latter. R. H. Richards mentions seven essential features of a perfect mechanical sampler, which are:

1. It must take the whole stream of ore (wet or dry) part of the time.

2. The scoop that cuts out the sample must move completely across and out of the stream in one direction at each cut, for, if it enters from one side, and is then withdrawn on the same side without having completely crossed the stream, more ore will be taken from the side at which the scoop enters and leaves than from the other side. He also adds that although such a scoop may take part of the stream at a given time, it does take a true section across the stream and virtually takes the whole stream part of the time.

3. The scoop must move at a uniform rate, and the top of the scoop must, in all positions, be at right angles to the direction of the stream, in order to take equal proportions from all parts of the stream. This condittion, he advises, is well obtained from a vertical stream and a horizontal scoop, in the case of a revolving scoop.

4. If the scoop that cuts out the sample revolves about an axis, two sides of the scoop should converge towards the

axis in order to take equal proportions from all parts of the stream and the scoop may be adjustable to take larger or smaller proportions of the ore.

5. The interval of time between cuts should be constant.

6. The scoops must be deep and broad enough so that ore that has once gotten into them will not bound out again; and if the scoops have closed bottoms they must not be allowed to fill up so that some of the ore runs over, as this would produce a concentration of the heavy minerals, especially when the ore is carried in running water.

7. The machine should be simple and easily accessible for cleaning, to avoid danger of contaminating subsequent samples.

There are some samplers now used in mills and smelters that cover all of these points mentioned by Dr. Richards in his "Text Book on Ore Dressing." Such samplers are the Snyder, the Vezin and the Brunton.

As hand sampling requires much more labor than mechanical sampling, it is more costly, and it is impossible to have an intentional error in the case of mechanical sampling.

The size of a sample depends largely on the character of the ore. If the metal values are very evenly distributed throughout the ore, a smaller sample is required than when this is not the case. From this it will be clear that the weight of the sample taken will decrease as the size of the ore particles decrease.

A considerable part of the ore is crushed fine when mechanical sampling is used, and since such fine material is undesirable in the blast furnace, lead smelters, which heat all of their ore by blast furnaces, still use hand sampling almost exclusively in the case of oxide ores. This, however, is not the case with the sulphide ores that come to a lead

smelter, because they have to be roasted and sintered before smelting, and finely crushed ore facilities roasting. Thus it is customary in a lead smelter to use mechanical sampling on the sulphide ores and hand sampling on the oxide ores.

The following describes the method of sampling in use at the Tigre Mining Co., as described in the Engineering & Mining Journal of June 6, 1914. "The sorted high grade and sorted waste are grab-sampled; the ore on its way to the mill is sampled automatically in a revolving sampler of the slotted-cone type; the concentrate is sampled by the "cheese-trier" method; the stamp mill tailings is sampled by a Scobey-sampler and the dump tailings are uniform and sampled three times per shift by hand. The bullion is sampled by dipping; the precipitate by the same method as the concenerate, and the cyanide by hand, in the tailings sluices at each discharge of the filter press. Pregnant solutions by dropping a weighted bottle into the stump tanks, but barren solutions by drip methods."

The method of sampling at the Nipissing mill is as follows: The ore is automatically sampled on its way to the desulphurizing process. The pulp is sampled by cutting the stream every six minutes.

SAMPLING AT EL PASO SMELTERY

The first sampling is done by hand during the operation of unloading. Here each fifth or tenth shovel is thrown onto the sample heap. On the concentrates each fifth shovel is taken and this sample is halved. The shovel samples are taken to the sample mill, while the concentrate samples go to the quartering floor, where they are sampled according to the coning and quartering method. The final sample here weighs about 400 pounds.

The shovel samples from the ore lots are reduced in some automatic sampling and crushing equipment. There are four sets of such automatic sampling and crushing equipments, two for ores not exceeding three inches in size, and two for coarse material.

"The samples from the finishing rolls are dried in two stream drying rooms, and thence go to two backing rooms. The duplicate samples are handled in different rooms. These rooms have four Engelbach grinders and four Eaton pulp mixers. The latter are small revolving cylinders, having several interior shelves to assist in mixing the material. From the Eaton mixer the sample is riffled down on a Jones divider and then goes to the bucking board. From the bucking board the pulp returns to a small Eaton mixer and after being revolved for a few minutes, the material is poured out and the sample is placed in the pulp envelopes.

In the above stated cases, sampling methods have been outlined as used both in the mill and in the smelter. Hand sampling can be done very conveniently in both cases, and also mechanical, but there is a better chance to get running samples in a wet-concentrating plant than there is in the case of a smelter, where the ore usually comes in in the form of dry shipments. To what extent mechanical sampling should be carried on depends greatly upon the mechanical perfection of the samplers used, especially with respect to cleanliness and to their adaptability to make the loss, which is brought about by the extreme fineness of the material, as small as possible.

In conclusion it may be worth while to point out how impractical it is for a smelter to underpay any party from whom ore is bought, as some, who have small quantities of ore for sale, very often imagine. A smelter is always willing to present a seller with half of the sample obtained at the smelter, in order that he himself can have the sample assayed, and if his results should not agree with those obtained at the smelter, the latter is furthermore willing to refer the whole matter to an umpire assayer. The regular procedure of operations as carried out at a smelter makes it almost an impossibility to get such a false sample as to specially favor itself, and this, together with its willingness to have its own assay results confirmed by the seller, makes the practice of under pay-

ing the owners of ores very much impractical. From this one concludes that when a man has some ore which he wishes to sell to a smelter, the latter will almost without exception, give him full value for his property.

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The Selling of Copper

BY

H. J. STANDER

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THE SELLING OF COPPER

BY H. J. STANDER

When a metal takes such marvelous leaps in its price as copper has been doing during the last several months, it draws the attention of people who otherwise are not at all interested in the production, working and selling of that particular metal. Just at the present time all mining men, mining engineers and others are watching the price of copper with very great interest.

Before anything can be done with regard to the selling of an ore, it is necessary to know its composition as accurately as possible. In the case of a copper ore, one must know not only the percentage of copper or copper sulphide present, but also the percentages of all the other materials, because some substances in the ore may bring a bonus, whereas one is penalized for other substances should they happen to be present in the ore. The amount of both the bonus and the penalty will depend upon the percentages in which such substances appear. The basis on which the price of the ore is estimated is the price of the refined metal at the time the valuation is made, as quoted by some principal market center, such as New York.

It is very important to know the contents of an ore in gold, silver, copper, lead and zinc, if some or all of these metals be present. The ore is also quantitatively analyzed for the following: silica, sulphur, iron, alumina and lime, and sometimes also for antimony, arsenic, magnesia and barium. It is in lead and copper ores especially that one must know within narrow limits the amounts, in both the ores and the flux, of the silica, lime, magnesia, sulphur, iron and alumina, in order to control smelting operations.

After the percentages of all these substances have been determined, and the composition of the ore has been decided and agreed upon by the parties interested, it becomes possible for them to agree upon the valuation of the ore, and this valuation, as stated above, is also based upon the price of the refined metal, as quoted by the market at the time the valuation is made.

To obtain the gross value of the ore, one gets the sum of the products obtained by multiplying the metal contents, in pounds for the base metals and in troy ounces for the precious metalls, per avoirdupois ton

by the prevailing price of the refined metals. To obtain the net value of the ore, the total cost of mining it, together with the charge for treatment is deducted from the gross value. The cost of treatment is determined by considering the freight charges to the treatment plant, the milling or smelting charges, compensation charges for loss of metal during the process of treatment, penalties on undesirable substances in the ore, freight charges to the refinery, charges for refining the metal, and charges for the selling of the refined metal. It thus becomes necessary for the buyer and purchaser, before they can agree upon the valuation of the ore, to consider some or all of these items.

Considering the cost of capital invested, labor, power, repairs, depreciations, etc., it is possible to ascertain a basic smelting charge per ton of ore, reckoning also a certain sum per ton for furnace charge. It is upon such a basic smelting charge that the smelting rates are based. Should an ore contain an excess of silica, a penalty is imposed based upon the amount of silica in excess of that which the furnace charge ought to contain, because, in order to take care of this excess amount of silica, the smelter has to provide an iron or lime flux. The amount of the penalty will then simply be the cost of this flux. Now very often the ore itself contains an excess of iron, and by an excess of iron is meant an amount of iron in the ore more than is required for the ideal furnace charge, and in such a case the excess quantity of iron may be sufficient to flux the excess amount of silicia. In other words, the excess amounts of silica and iron just neutralize each other in the furnace charge, with the result that no penalty need be imposed. From this one will see that the mining of silicious and ferruginous ores need not necessarily be detrimental. This basis of determining smelter charges is known as the "neutral schedule."

It is easy to see that theoretically the smelter does not gain anything by using the 'neutral schedule," in the determination of the smelting charges, yet it very often means some profit to them. It is assumed that in the ideal furnace charge one part of silica fluxes there is one part of iron or lime, and this is true in the case of copper smelting. But a bonus paid on a unit, or 1% per ton, of excess iron is about 5 to 10 cents, whereas the penalty on excess silica is about 10 to 15 cents. Thus the smelter can never lose when it uses the neutral schedule system, because if the excess is silica, it is multiplied by the penalty per unit, and this product is added to the smelting charges; whereas, should there be an excess of iron, it is multiplied by the bonus per unit and subtracted from the smelting charge. This is one way of determining the final smelting charge. Some smelters have quite a different system. After having obtained the amounts of excess silica and iron

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respectively, they determine how much of either silica or iron there will be in excess, if every one part of the iron can be neutralized by one part of the excess silica present. Supposing that the excess amounts of silica and iron in the ore are in the ratio of 11 parts of silica to 10 parts of iron, the 10 parts of iron can be fluxed with 10 parts of silica, and the final excess of silica will then be 1 part. The seller is then penalized for this one part of excess of silica. Since the penalty on silica amounts to about 10 cents per unit, and the bonus on iron only to 5 cents, it is quite clear that such a method of calculating excess favors the silicious ore more than does the first system described above.

There are certain districts in which ferruginous ores are more common than siliceous ores, and in such cases the penalty may be placed on the iron, and the bonus given to the silica. Where silicious ores are in great demand, it is usually customary to base the smelting charge on the so-called "flat schedule." By a "flat schedule" is meant a fixed charge, paying no attention to the composition of the ore, as does the neutral schedule. The flat schedule is really based on an empirical value of the cost of smelting that particular ore, and since the percentage of the metal is never absolutely constant in an ore, the cost of smelting such an ore will vary with the amount of metal in it—in other words, the flat schedule is, in most cases, on a sliding scale. Thus, in the flat schedule the only thing considered is the percentage of metal in the ore, whereas the neutral schedule considers, besides this, the composition of the ore.

The smelting charges on high-grade ores are higher than those on the low-grade ores, when one considers the relative tonnage of each class. The smelting charges on low-grade ores are not much over the actual cost—in fact, in some cases, they are below actual cost. If, now, an average smelting rate had to be adopted, it would make it almost impossible to work very low-grade ores, and thus the sliding scale is the customary system used, because in such a case a low-grade ore can be worked much more profitably than when a melting charge, irrespective of the metal content, be imposed. One must, however, not forget that an increase in the metal content, means less gangue to be fluxed and the smelting operation then becomes cheaper. Thus, the smelter charges will decrease as the metal content increases, in the case of copper and lead ores, whereas this is not true to the same extent when the value of the ore is largely in gold.

In copper ores, the amount of copper present in the ore is usually determined by what is known as "wet analysis." Such a wet analysis can be carried out either electrolytically or volumetrically, and there are two volumetric methods, the iodide and the cyanide method. It is

also possible, however, to obtain the percentage of copper in an ore by a fire assay, but as the results are usually below the correct values, this method is not at all in general use. The smelter pays for the actual "yield" of copper in an ore, and this actual "yield" is usually the figure given by the wet analysis, less from 0.75 to 1.5%.

Thus, if an ore should contain copper less than, say 1%, the owner cannot expect the smelter to pay him for the copper in his ore. It is customary, then, to state in a contract on what basis the content of the metal shall be decided. Thus a contract may read that the percentage of copper in the ore shall be determined by the wet analysis less 1%. This would mean that if both parties agreed that the wet analysis on a given shipment of ore figured out to be 8.5% copper, the smelter will pay for only 7.5% copper in the ore, and 1% representing the loss in smelting as agreed upon in the contract.

The New York quotations on copper are always made on three types of copper. These types or bands are as follows:

I. Electrolytic copper—ingots and wire bars.

II. Electrolytic copper, not in the form of ingots or wire bars, but as cathods. This is simply the copper as deposited in its original form, without being welted afterwards.

III. Casting copper, which is only reasonably pure.

Cathode copper is usually quoted at about 0.1 cent and casting copper at 0.2 cent less than wire bars. The smelter's deduction for copper from the New York quotations are as follows, in the case of lead ores containing copper:

From 1.5 to 5% copper—6 cents off casting copper quotation.
From 5 to 10% copper—5 cents off casting copper quotation.
More than 10% copper—4 cents off casting copper quotation.
Whereas the figures for the copper contained in copper ores are:
From 1.5 to 5% copper——5 cents off electrolytic copper ore.
From 5 to 10% copper—4½ cents off electrolytic copper ore.
From 10 to 20% copper—4 cents off electrolytic copper ore.
From 20 to 30% copper—3½ cents off electrolytic copper ore.
Over 30% copper—3 cents off electrolytic copper ore.

In order to recover the copper in a lead ore, it is necessary to treat the matte formed in the lead blast furnace, because as the lead ore is smelted the heavy metal, lead, collects at the bottom and carries with it the gold and silver and a little copper; while a matte is formed on top of this and contains chiefly iron sulphide, copper and perhaps a small amount of gold and silver. Then there is, of course, the slag on top of the matte; but the point is that this matte, formed in the smelting of a lead ore, is different from that produced in copper smelting,

in that it contains some lead. To treat the matte from a lead furnace to recover the copper is more expensive than the cost of recovering the copper in the matte from a copper smelter. It is for this reason that the figures given above, dealing with the smelter deductions from market prices for copper in the case of a lead ore containing copper are higher than those given for a copper ore.

PENALTIES

The penalties with regard to silica and iron in copper ore have already been mentioned, and the other materials in a copper ore on which a penalty is imposed are zinc, arsenic and antimony.

In the copper smelter one cannot recover the zinc, as it passes into the fume and fine dust, and into the slag. The slag can contain as much as 10% zinc without any considerable detriment, but when there is more than 10% zinc in a slag, it becomes viscid and causes trouble. Zinc is also detrimental to the furnace itself, in that it forms incrustations in the furnace; and a further trouble brought about by the presence of zinc in a copper ore is that the zinc in volatilizing will carry some of the metal with it, as it causes volatilization of the copper also. The penalty on zinc is about 30 to 50 cents per unit above 10% zinc present. This means about 30 to 50 cents for every 20 pounds of zinc, about 200 pounds in a ton of ore. This is a very heavy penalty and encourages the separating out of the zinc in the mill, because it then becomes possible not only to escape paying the zinc penalty to the smeltler, but very often to make a zinc product which can be sent to a zinc smelter.

Arsenic is occasionally penalized in copper smelting, and this also applies to antimony. Both arsenic and antimony will form, together with the copper and iron, a so-called "speiss." This speiss is a very undesirable by-product in that it is very costly to treat for the recovery of the metals contained in it. A penalty is thus usually imposed on an arsenic and antimony content greater than 1%.

The main markets for copper are New York, London and Hamburg. All the big nations, with the exception of Russia, have agreed that no duty shall be imposed on either the importation or the exportation of copper, so that the copper market is the same throughout the world. The few selling agencies in New York handle almost all the copper produced, while there are only a few of the producers that sell their copper direct.

There are four kinds of copper sold; they are:

I. Lake copper, i. e., that coming from the Lake Superior district.

II Electrolytic copper. This is the refined copper, and these

copper refineries usually refine the copper coming from the west.

III. Pig copper.

IV. Casting copper.

These last two kinds of copper are somewhat impure, as the pig copper does not contain enough silver to pay for its refining and the casting copper is made from old scrap copper. As has been mentioned before, there are two kinds of electrolytic copper, the bars and the cathode, but the cathode copper is somewhat uncommon at the present time. Lake copper still has a premium of about ¼ cent over electrolytic copper, although the electrolytic copper is very often better in its electrical conductivity than the Lake copper, but this premium is perhaps only a result of the reputation the Lake copper has had in the past.

THE FORMS IN WHICH COPPER IS MARKETED

I. Pigs, similar to the pigs of cast iron, weighing 100 pounds each.

11. Rectangular cakes of different sizes.

III. Ingots, like the pigs, but partly divided into two or three sections, so as to make it easy to break it for introduction into crucibles used for melting.

IV. Ingot bars, partly divided into 3 to 5 parts. These bars weigh from 60 to 90 pounds.

V. Wire bars, tapering towards one end.

"OPEN SCHEDULES" FOR COPPER-LEAD-GOLD-SILVER ORES

The schedules given below are in force in the western sections of the United States.

1. Lead-copper ores, containing gold and silver. *Neutral schedule.*
   Gold, $19.50 per ounce of 0.05 ounce or over per ton.
   Silver, 95% of contents, date of assay.
   Lead (dry)—Prices are based on $4 quotation.
   Copper—For dry copper, which is 1.5% off wet, 6 cents off per pound on Western Union quotation for casting copper.
   Zinc—10% allowed, and 50 cents penalty per unit, in excess of this.
   Silica—Penalty, 10 cents per unit; iron bonus, 10 cents per unit.

11. Copper ores containing gold and silver. *Neutral schedule.*
   Gold—$19 per ounce if product contains 0.03 ounce or over per ton.
   Silver—95% of contents at New York quotation, date of assay.
   Copper—As per wet assay, less 1% of unit, at the price for

Cathode copper quoted in the Engineering & Mining Journal, issue of week previous to date of receipt, less 2½ cents per pound. (This price changes according to supply and demand conditions.)

Iron—Paid for at 10 cents per unit.

CHARGES

Insoluble—10 cents penalty per unit.

Zinc—10 per cent allowed free; excess at 25 cents per unit.

Speiss—10 per cent allowed free; excess at 25 cents per unit.

Treatment charge—$3 per ton.

The above prices are an average but vary considerably under local conditions. For instance, many localities may have an excess of silicious ores which will cause an increased bonus to be paid for iron ores, and vice versa, districts supplying large quantities of ores heavy in iron may have a larger percentage of silica without penalty.

The ascertaining of a correct smelter charge takes so many factors into consideration that it is generally misunderstood by the seller of ore; he ordinarily believes that he should merely be paid for the copper, gold and silver and whatever other metals it contains, not realizing that in smelting operation it is impossible to obtain all of the copper; that in selling the metallic copper the full quoted market price is not obtained; that the copper produced at the smelter is not purified copper ready for the market; that there are many things in the ore which cause additional flux, which contain no value to be purchased and handled.

In order to successfully operate a smelter, the mixtures going to the furnaces cannot be varied from hour to hour or even from day to day; hence to get the proper mixture of ores, the smelters desire large and regular shipments. A small shipment is as much work for the assaying and general charges as a large shipment; hence it is not unreasonable to expect that the costs of smelting will be greater for small shipments. Small shipments influence the mixtures and often upset considerable routine operation. In the case of the excessive supply, and the working of the smelters to their fullest capacity, it is often true that smelters will refuse to accept small, irregular shipments.

Another point generally misunderstood is the fact that while the smelter is paying for ores received, based on prices upon the day or week of the purchase, they do not receive the payment for the metal produced for some 90 or 100 days—hence fluctuations on the market must play a very considerable part in the fixing of smelter prices.

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The Selling of Lead and Zinc

BY
H. J. STANDER

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THE SELLING OF LEAD AND ZINC

By H. J. STANDER.

THE SELLING OF LEAD.

The lead industry in 1915 made good gains in output, both in mining and smelting. The lead content of ore mined in the United States was apparently over 600,000 short tons, compared with 522,864 tons in 1914, an increase of 78,000 tons, or 15 per cent. With the higher prices prevailing the percentage of increase in value of the 1915 output was even greater as compared with other years.

During 1915 construction was begun on one lead smelter and plans were completed for another, both to treat ore from the Coeur d'Alene district of Idaho. The Hercules Mining Co. purchased the copper smelter at Northport, Wash., and began the construction of two lead furnaces. This company is affiliated with the Pennsylvania Smelting Co. of Pittsburgh, Pa. The Bunker Hill & Sullivan Co. of the Coeur d'Alene district also completed plans for a smelter, but the site is yet in abeyance. The National refinery of the American Smelting & Refining Co. at Chicago, was dismantled, and the Balbach Smelting & Refining Co. abandoned its older lead plant at Newark, N. J.

The following estimates have been compiled by C. E. Siebenthal from reports to the United States Geological Survey by all the lead refineries and soft-lead smelters in operation during the year, except two smelters in the Joplin district, for which estimates have been made. These reports cover actual production for the first 10 or 11 months of the year, with an estimate for the remainder of the year, and from them the figures of production are made up without change. The statistics of imports, exports, and lead remaining in warehouse have been taken from the records of the Bureau of Foreign and Domestic Commerce for 10 months, the figures for November and December having been estimated.

LARGEST PRODUCTION TO DATE.

The production of refined lead, desilverized and soft, from domestic and foreign ores in 1915 was approximately 565,000 short tons, worth at the average New York price $53,110,000, compared with 542,122 tons, worth $42,285,500, in 1914, and with 462,460 tons in 1913. The figures for 1915 do not include an estimated output of 20,550

tons of antimonial lead, worth $1,886,000, against 16,667 tons in 1914, and 16,665 tons in 1913. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, is estimated at 306,682 tons, against 311,069 tons in 1914 and 250,578 tons in 1913; and desilverized lead of foreign origin at 48,318 tons, compared with 29,328 tons in 1914 and 50,582 tons in 1913. The production of soft lead, mainly from Mississippi Valley ores, is estimated at 210,000 tons, compared with 201,725 tons in 1914 and 161,300 tons in 1913. The total production of lead, desilverized and soft, from domestic ores, was thus about 516,682 tons, compared with 512,794 tons in 1914.

The final figures for the production of soft lead will show an increase of a few thousand tons over those here given, for the reason that the smelters and refiners of argentiferous lead undoubtedly treated more or less soft lead from the Mississippi Valley which is not distinguished from silver-lead ores in their preliminary estimates.

IMPORTS AND EXPORTS.

The imports of lead are estimated at 9,625 short tons of lead in ore, valued at $653,000; 50,825 tons of lead in base bullion, valued at $3,496,000; and 400 tons of refined and old lead, valued at $28,000—a total of 60,850 tons, valued at $4,177,000, compared with 28,338 tons in 1914. Of the imports in 1915 about 58,000 tons came from Mexico, against 23,141 tons in 1914. These imports from Mexico are to be compared with an average of over 100,000 tons before the civil strife in that country. The remaining imports of lead came mostly from Chile.

The exports of lead of foreign origin smelted or refined in the United States again show an increase, being estimated at 43,000 tons, against 31,051 tons in 1914 and 54,301 tons in 1913. For the last two years, on the other hand, notable quantities of domestic lead have been exported to Europe, and the total for 1915 is estimated at 76,000 short tons, valued at $6,650,000, compared to 58,722 tons, valued at $4,501,674, in 1914.

LEAD AVAILABLE FOR CONSUMPTION.

The amount of lead available for consumption during 1915 may be estimated by adding to the stock of foreign lead (domestic stocks are not known) in bonded warehouses at the beginning of the year (7,668 short tons) the imports (about 60,850 tons), the additions by liquidation (1,795 tons), and the domestic production (516,682 tons, making an apparent supply of 587,000 tons. From this are to be subtracted the exports of foreign lead (about 43,000 tons), the exports of domestic lead (76,000 tons), and the stock in bonded warehouses

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at the close of the year (assumed to be the same as at the close of October, 16,000 tons), leaving as available for consumption 452,000 tons, compared with 449,052 tons in 1914.

HIGH PRICES.

Lead began the year at New York with a price of 3.8 cents a pound, nearly the minimum price of the year, and remained practically stationary until the middle of February. A gradual rise brought the price to 4.2 cents in April, and it remained there until the later part of May. A rapid rise next followed, and lead reached the maximum for the year at 7.56 on June 14. A sharp decline, followed by partial recovery and then by a more general decline, brought the price to 4.4 cents in the later part of August. After a slight recovery and another decline to 4.45 cents in September, the price gradually rose and closed the year at about 5.4 cents. The average New York price for the year was 4.7 cents a pound, compared with 3.9 cents in 1914 and 4.4 cents in 1913.

The London price of lead started at £19 a long ton (4.1 cents a pound) and rose until the latter part of March, when it reached £23 2s. 6d. a long ton (5 cents a pound). From this point the price fell to £20 1s. 3d. a long ton (4.3 cents a pound), after which there was a sharp ascent to £28 2s. 6d. (6.1 cents a pound) at the middle of June. After several ups and downs the price dropped to £20 6s. 3d. (4.4 cents a pound) by the middle of August, and then a gradual rise carried it to £29 5s. a long ton (6.3 cents a pound), and it closed the year at about that figure. The London market was fairly parallel to the New York market and, except for the period of high prices in the United States during July and August, was uniformly higher than the American market.

There are three forms of commercial lead:

1. The ordinary refined lead.
2. Corroding lead. This is especially pure.
3. Antimonial lead. This last kind of lead contains about 17 per cent of antimony, and is largely used in type metal.

The two lead markets in the United States are New York and St. Louis, and the difference in the prices quoted from these two places will, of course, be the freight rate, i. e., about 15 cents per hundred pounds.

PENALTIES.

As in the case of copper ores, there is a penalty for each of the following substances found in excess in a lead ore: zinc, arsenic and antimony; but besides this there is also a penalty on sulphur content greater than 3 per cent, and the penalty is usually 20 cents per unit

above 3 per cent of sulphur content. The reason for this is that while sulphur is necessary for the smelting of copper, it is not at all necessary in lead smelting. When there is a large amount of sulphur in a lead ore, it becomes necessary to first roast the ore before it can be smelted, and this, of course, costs considerably. Thus a smelter will allow usually only 3% of sulphur in a lead ore, as such a small quantity of copper can be gotten rid of in the smelting process, without going to the expense of first roasting the ore.

The proportion of lead in an ore or concentrate can be determined in one of two ways:

1. Wet analysis. By this means one gets what is commonly called the "wet lead," and the results of a wet analysis on a lead ore usually represents the actual amount of lead present.

2. Fire assay. This is the older of the two methods, and really gives the amount of lead in the ore as will be obtained in the actual smelting process.

One will usually find that the results obtained from a wet analysis are about 0.7 per cent higher than those obtained from a fire assay determination, when the ore does not contain any appreciable amounts of easily reducible metals, such as copper, antimony, bismuth, arsenic and zinc. When, however, the ore is fairly "impure," i. e. it contains an appreciable amount of the above-mentioned metals, some of these metals are reduced with the lead, in the case of a fire assay. The quantity of lead then obtained will be too high, as it will have in it whatever amount of these metals that has been reduced, so that the results may be fairly incorrect. Thus when a smelter buys lead ore that contains a large amount of such easily reducible metals, it always wishes to do so on the basis of the wet analysis, because the amount of lead present, as given by this method, will then be less than that obtained by a fire assay. But in the case of a "pure" ore, the fire assay gives the lower figures for the percentage of lead in the ore, and in the case of the "pure" lead ores, one can see that the smelter will always be desirous of buying the ore on the fire assay basis, whereas the seller's attitude in this matter, will, of course, be just the opposite from that of the smelter.

The following method for determining the percentage of lead in the ore is the one in common use now, in order to overcome the difficulties arising from the different results as obtained from wet analysis and fire assay determinations in the case of different kinds of lead ores.

1. Pure Lead Ores. The fire assay method, although both buyer and seller can get checks on the fire assay figures from wet analyses.

2. Other Lead Ores. (a) Fire assay, but the lead in the button is determined by wet analysis. (b) Wet analysis, with a deduction of from 1 to 1.5 per cent.

The smelter usually pays only for 90 per cent of the lead content, determined either by the fire assay or wet analysis, less about 1.5 per cent, which is usually called "the dry analysis basis." The smelter pays only for 90 per cent of the lead content because of such a great amount of smelter losses that always take place in the case of lead smelting. These losses amount to from 5 to 15 per cent of the lead smelted, and the losses in the case of a high grade ore are always relatively less than those in the case of a low grade lead ore.

NEUTRAL SCHEDULE ON LEAD IN LEAD ORES AND LEAD-COPPER ORES.

Lead Content	Value per Unit	Smelter Charge per Ton
5 to 10%	40 cents	$6.00
10 to 15%	43 cents	5.00
15 to 20%	45 cents	4.00
20 to 25%	47 cents	3.00
25 to 30%	49 cents	3.00
30 to 35%	51 cents	2.00
35 to 40%	52 cents	1.50
40 to 45%	52 cents	1.00
45 to 50%	53 cents	1.00
50 to 55%	54 cents	1.00
Over 55%	55 cents	1.00

FLAT SCHEDULE ON LEAD IN LEAD ORES AND LEAD-COPPER ORES.

Lead Content	Value per Unit	Smelter Charge per Ton
5 to 10%	40 cents	$10.00
10 to 15%	43 cents	8.50
15 to 20%	45 cents	7.00
20 to 25%	47 cents	5.50
25 to 30%	49 cents	4.50
30 to 35%	51 cents	3.50
35 to 40%	52 cents	2.00
40 to 45%	52 cents	1.00
45 to 50%	53 cents	1.00
50 to 55%	54 cents	1.00
Over 55%	55 cents	1.00

SCHEDULE ON LEAD CONCENTRATES.

Lead Content	Value per Unit	Smelter Charge per Ton
5 to 10%	40 cents	$3.75
10 to 15%	43 cents	3.00
15 to 20%	45 cents	2.50
20 to 25%	47 cents	2.25
25 to 30%	49 cents	2.75

In all cases, the following is usually the schedule on which payment for gold, silver and copper in the lead ores:

Gold, $19.50 per ounce, if 0.05 ounce or over per ton.

Silver, 95% of contents at New York quotation, date of assay.

Copper, for dry copper (1.5% off wet) and 6 cents off per pound on Western Union quotation for casting copper.

The payment for the amount of lead in the ore is made in one of three different methods: They are:

1. By the unit and at quotation.
2. For 90% of lead content at the sales price, with a deduction per pound.
3. For 90% of lead content at 90 or 95% of the sale price.

The price per unit is based on a quotation of $4 per 100 pounds of lead. For every rise of 5 cents in the quotation, 1 cent is added to the price per unit, and in the same way, 1 cent is deducted from the price per unit for every fall of 5 cents in the quotation.

One must remember that the quotation is not the sales price in New York, but is 90% of this price. So that when the New York sales price is $4 per 100 pounds, the quotation is 90% of $4, i.e. $3.60. When, however, the sales price is below $4.50 and over $4.00, the quotation is obtained by taking 90% of the $4 sales price, and adding to it one-half of the excess of the sales price over $4. Again, when the sales price is above $4.50, the quotation is 90% of $4, i. e. $3.60, plus one-half the excess of the sales price between $4 and $4.50, plus the excess above $4.50.

Usually no payment is made for a lead content of less than 5% in an ore. Sometimes, however, a bonus of 15 cents per unit is given for lead in an ore, if the lead content is below 5%. Since the losses are comparatively greater in smelting low grade ores than in smelting high grade ores, the smelter usually pays a lower price per unit for the lead in low-grade lead ores than for the lead in high grade ores.

SELLING OF ZINC.

The common term for commercial zinc is spelter. All the great zinc fields and a great number of the zinc smelters are situated in Missouri and not far from St. Louis; for this reason, St. Louis, Mo.,

is the main zinc market. It is, however, also sold in New York, but on a St. Louis basis.

It is essential in the case of zinc that the ore be of a high grade character, because too low grade zinc ores cannot be treated at the zinc smelter directly. In the United States zinc is chiefly produced in Missouri, Wisconsin, Colorado and Montana. Bids are always made in the open market, and smelters usually have representatives who offer prices for given lots of ore. There are two standard zinc ores:

1. The 60% ore, which is commonly zinc sulphide, or what is called "blende."
2. The 30% ore, which is zinc silicate, or calomine.

PENALTIES.

Lead is sometimes penalized when present in a proportion above 0.5%; iron, when present over 1%, is penalized at the rate of $1 for each one per cent above this figure.

The New York price for zinc is the price quoted at St. Louis, plus 15 cents per hundred pounds, which is the freight rate on spelter from St. Louis to New York. Spelter is protected by an import duty of 15 per cent ad valorem, and the zinc ore by a duty of 10 per cent ad valorem.

The Engineering & Mining Journal, Jan. 10, 1915, published the accompanying table, giving the names and capacity of the zinc smelters in the United States. Their capacity is calculated from the number of retorts at the end of 1914.

Name of Plant.	Situation	No. of Retorts
Altoona Zinc Smelting Co.	Altoona, Kans.	3,845
American Zinc & Chemical Co.	Longcloth, Pa.	864
American Zinc Co. of Illinois	Hillsboro, Ill.	400
American Zinc, Lead & Smelting Co.	Dearing, Kans.	3,840
American Zinc, Lead & Smelting Co.	Caney, Kans.	3,648
Barblesville Zinc Co.	Barblesville, Okla.	5,184
Barblesville Zinc Co.	Collinsville, Okla.	8,064
Channbe Zinc Co.	Channbe, Kans.	1,780
Clarksburg Zinc Co.	Clarksburg, W. Va.	2,712
Collinsville Zinc Smelting Co.	Collinsville, Ill.	1,536
Edger Zinc Co.	St. Louis, Mo.	1,180
Edger Zinc Co.	Cherryville, Kans.	4,800
Granby Mining & Smelting Co.	Neodeska, Kans.	3,840
Granby Mining & Smelting Co.	E. St. Louis, Ill.	3,240

Grasselli Chemical Co.	Clarksburg, W. Va.	12,672
Grasselli Chemical Co.	Meadowbrook, W. Va.	
Hegeler Bros.	Danville, Ill.	1,800
Illinois Zinc Co.	Peru, Ill.	4,640
La Harpe Spelter Co.	Le Harpe, Kans.	1,856
Robert Lanyon Zinc & Acid Co.	Hillsboro, Ill.	1,840
Layone Starr Smelting Co.	Barblesville, Okla.	3,456
Matthiesen & Hegler Zinc Co.	La Salle, Ill.	5,256
Mineral Point Zinc Co.	Depue, Ill	9,080
National Zinc Co.	Barblesville, Okla.	4,260
National Zinc Co.	Springfield, Ill.	3,200
Nevada Zinc Co.	Nevada, Mo.	3,648
New Jersey Zinc Co.	Palmerton, Pa.	5,760
Pittsburg Zinc Co.	Pittsburg, Kans.	910
Prime Wesborn Spelter Co.	Gas City, Kans.	4,768
Sandoval Zinc Co.	Sandoval, Ill.	6,896
Tulsa Fuel & Manufacturing Co.	Collinsville, Okla.	4,232
Tulsa Spelter Co.	Sand Springs, Okla.	4,000
United States Zinc Co.	Pueblo, Colo.	1,920
Total		120,994

There are four kinds of spelter on the market:

		% Lead	%. Iron	% Cu	% Impurities
I.	High grade or A	0.07	0.03	0.05	0.10
II.	Intermediate or B	0.70	0.03	0.05	0.50
III.	Brass Special or C	0.75	0.04	0.07	1.20
IV.	Prime Western or D	1.50	0.08	....	....

The high grade spelter is usually from 2 to 4 cents per pound more than that of the prime Western; intermediate spelter is from 1 to 2 cents more per pound than prime Western. The prime Western is used chiefly for galvanizing iron, steel wire and iron flake.

The total production of spelter by ore smelters in 1914 was 362,361 tons, and there was a larger exportation of spelter than ever before in the history of the United States, the total being 70,242 tons, including 5,580 tons of spelter smelted in bond. These figures are from the "Mineral Industry" of 1914.

In conclusion, it may be worth while to give an example of a schedule of smelter charges for treatment of all classes of ore. The following schedule is typical of some of those in force in the western sections of the United States:

Gross Value Per Ton of Ore	Treatment Charges Per Dry Ton
Under $14	$ 5.00
$14 to $20	6.00
$20 to $25	6.50
$25 to $30	7.00
$30 to $35	7.50
$35 to $40	8.00
$40 to $45	8.50
$45 to $50	9.00
$50 or over	10.00

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